FLOOD FORECASTING TOOL CATEGORY DESCRIPTIONS

Advance warning of flood levels and impacted areas that are possible from an approaching storm greatly enhances the ability of individuals and communities to respond in appropriate ways to protect life and property. These responses include such things as evacuation while roads are still passable, sand bagging around areas before the water reaches a structure, and selection of areas requiring flood response assistance.

The National Weather Service (NWS) has the responsibility of weather forecasting and warning and has developed several related products on the internet for use by the public. The United States Geological Survey (USGS) and others have also developed products that complement the NWS products and enhance the information that can be obtained. Those products that are pertinent to flood forecasting in Indiana are described in this section. These products can be accessed from multiple web pages. Only one of the possible addresses to access a given product is provided. Work is under way by various entities to expand these capabilities in the future. Currently, these products provide the following types of information:

- spatial distribution of forecasted rainfall depths or snowfall water equivalent
- the rainfall that would be generally required in an area to create flooding based on the ground moisture conditions
- forecasted river stages at USGS stream gages
- expected extent and depth of flood inundation along select stream reaches at various stages recorded or forecasted at associated USGS stream gages
- information regarding the level of uncertainty in the forecasted river stages

Different streams have different combinations of products and data available for use in flood forecasting. In order to organize the descriptions of how to access the different products for use with each other, the different combinations of products available were grouped together in different categories. **Table 1** shows the products that are available in each category. A discussion of the use of the products for each category is then provided.

Table 1: Flood Forecast Product Availability

Flood Forecast Category	USGS gage is NWS river forecast point	Forecast Uncertainty Information	USGS inundation map library	CBBEL depth maps tied to USGS stream gage stages	CBBEL depth maps	USGS gage measuring real time stages	Precipitation forecast for the watershed	Flash flood guidance
A	√	(√)	√	√		√	√	√
B			√	√		√	√	√
C				√		√	√	√
D					√		√	√
E							√	√

Forecast Product Category A

Streams with this category of Forecast Products have the ideal set of tools for flood forecasting. This is because of the existence of a USGS gage on the stream that is included as a river forecast point by the NWS and an inundation map library developed by the USGS. Use of these tools is described below.

Every day, the NWS is using their methodology to make precipitation forecasts. Additional staff at the NWS then use other models to turn those precipitation forecasts into forecasted stages at select USGS stream gaging stations. As precipitation forecasts and ground moisture conditions change and river stages are observed in response to rainfall, the forecasted river stages are revised. These forecasted river stages in conjunction with flood inundation mapping can be found on the internet in the Flood Inundation Mapper currently accessible at wim.usgs.gov/FIMI/.

This web address displays the screen shown in **Figure 1**.

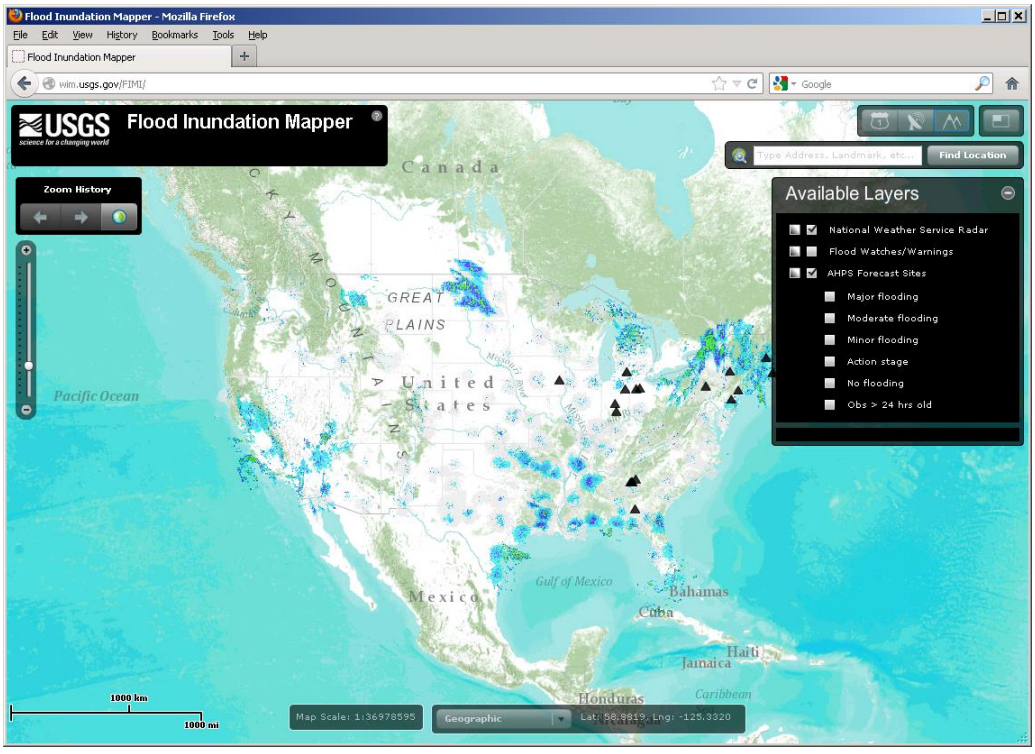

Figure 1: USGS Web Page for Selecting USGS Inundation Mapping

Using the magnifying glass icon in the upper right hand corner allows easy zooming of the map to a particular city if that city and state are typed in and the “find location” button is clicked. Zooming out an extent using the slider bar on the left side of the page will show more of the locations of available information noted by a black triangle. As an example of the data that will be provided when a black triangle is clicked on, a screen shot of the results from clicking on the Driftwood River at Edinburg gage is shown in **Figure 2**.

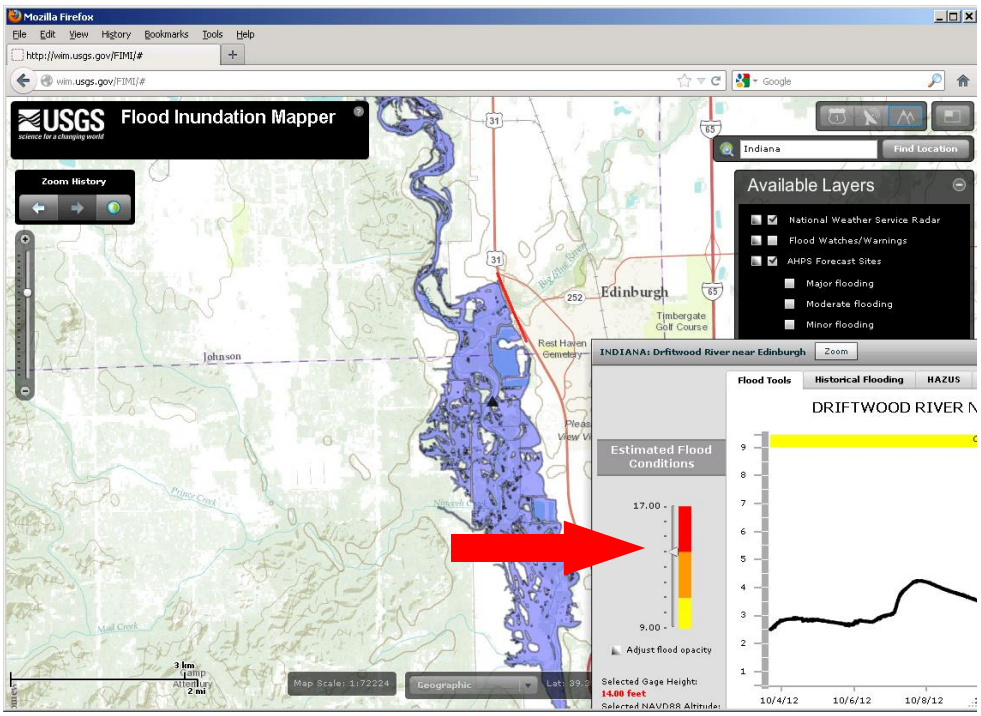

Figure 2: Expected Inundation Area if Flood Stage at Driftwood at Edninburg Gage Reaches Stage of 14 Feet

Movement of the stage slider bar noted with the red arrow causes the corresponding mapping to change to match the selected stage. If the box is moved completely on to the screen as shown in **Figure 3** the recent observed stages can be seen along with forecasted stages. Points on the graph to the left of the center blue line represent observed stages. Points to the right indicate forecasted stages.

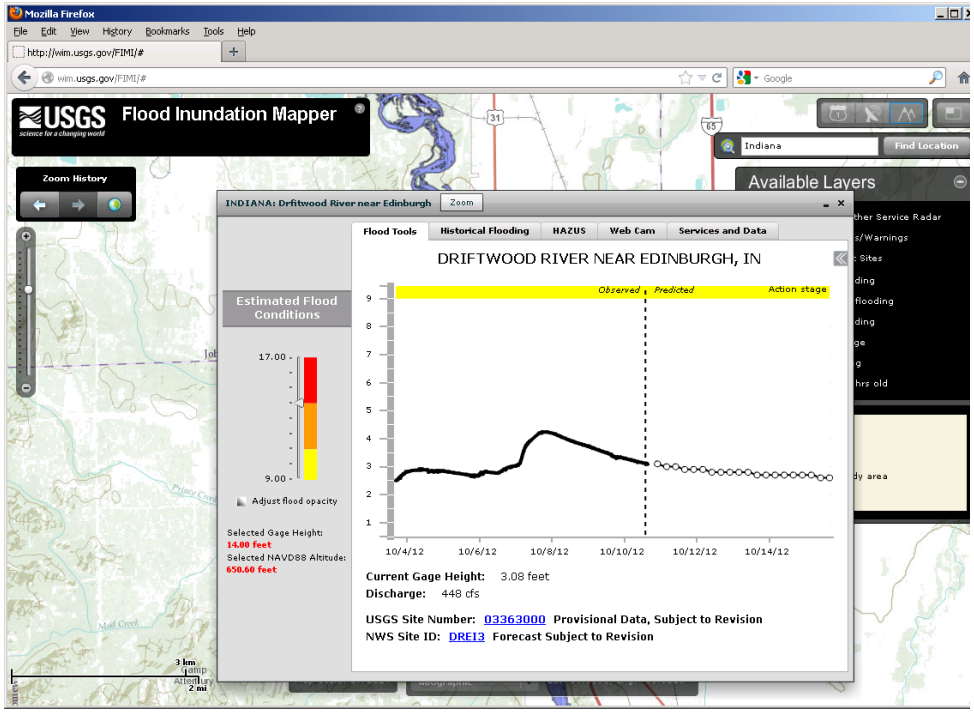

Figure 3: Example of Web Site Observed & Forecasted Stage Data

The inundation area associated with a forecasted gage stage can then be selected by use of the slider bar on the left. The inundation map then provides an approximate outline of the expected flood areas for the noted forecasted gage stage. Flood depths can be determined by clicking on points of interest. This data can be used by the public as well as emergency responders for determining the level of preparedness that is needed if conditions proceed as forecasted. Topographic, satellite, or street backgrounds can be used for the map by clicking the appropriate icon on the top right part of the page.

The inundation maps can be accessed from the web or downloaded to local computers for access should the web service be a problem when the information is needed. The options for downloading are provided by clicking the “services and Data” tab shown by the red arrow in **Figure 4**.

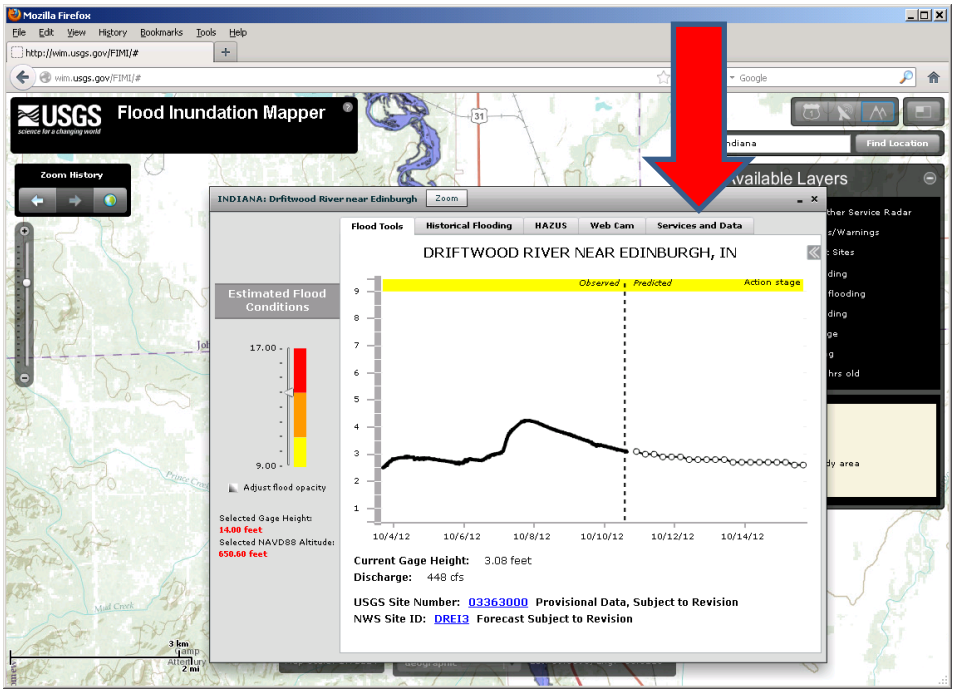

Figure 4: Location for Download of Inundation Mapping Files

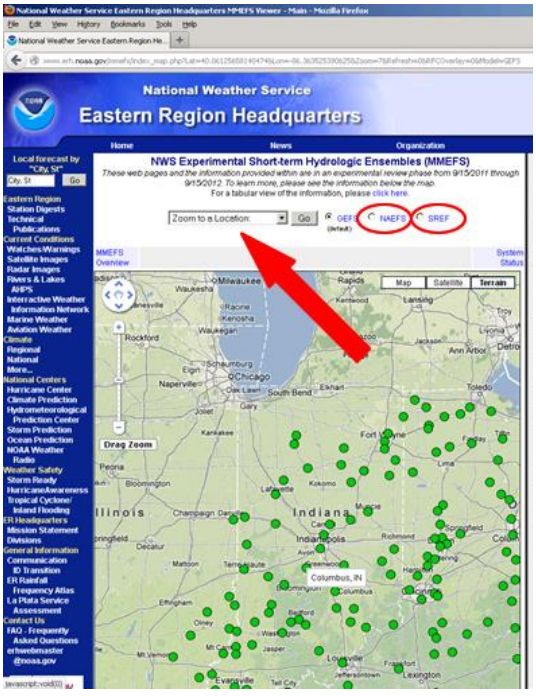

Figure 5: Web Page for Accessing NWS Data on Forecast Uncertainties

The process described above is based on the NWS's best estimate of the predicted rainfall and resulting river stage. Because each storm system is different and can be predicted with varying levels of certainty, the NWS has developed an experimental product that provides the forecast along with information regarding the associated uncertainty. This product (called the Experimental Short-term Hydrologic Ensembles (MMEFS)) can currently be accessed at the web address www.erh.noaa.gov/mmefs/. This address currently accesses the screen shown in **Figure 6**.

In the box "zoom to a location" (shown by the red arrow) select "Indiana" and one of the three four letter choices to the right. The NWS recommends NAEFS for 7 day forecasts and SREF for 2 to 3 day forecasts. Clicking on the "go" button near the red arrow zooms the map to Indiana and shows all of the available forecast points. The color and shape of the icon for each site indicates the probability of exceeding the action stage for the gage. The legend for the colors and shapes is provided lower on the web page.

Clicking on an icon brings up several forecast products in the form of graphs. The first graph, shown in **Figure 6,** "Stage/Flow Expected Values Plot" shows the stage (read from the left vertical axis) that the NWS gives a 25 to 75% chance of being reached. The taller the blue rectangle for each day, the more uncertainty there is in the forecasted stage. If the blue rectangle for two days in the future, for example, ranges from between stages of 15 and 16 feet, then there's a good chance the flood stage will reach at least 15 feet. Use of the 15 feet or 16 feet stage inundation maps previously discussed would then indicate the probable flood extents for that point in time.

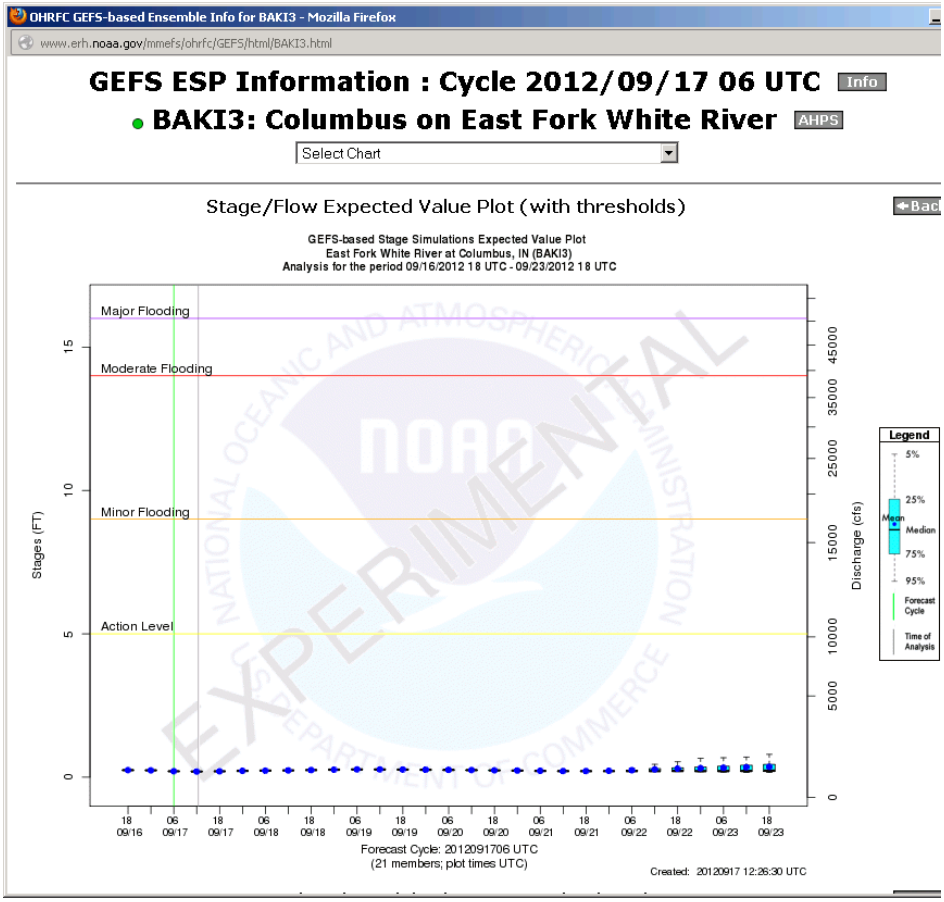

Figure 6: Range of Uncertainty for Forecasted Stage at USGS Gage

Another way to look at potential for flooding is the use of the third graph, shown in **Figure 7** and titled "Stage/Flow Probability of Exceedance". This graph shows the probability of any given stage (along the left axis) being exceeded in the forecast period noted below the graph title. The longer the flat line portion, the more certain the forecast of that stage as the maximum stage expected for the forecast period.

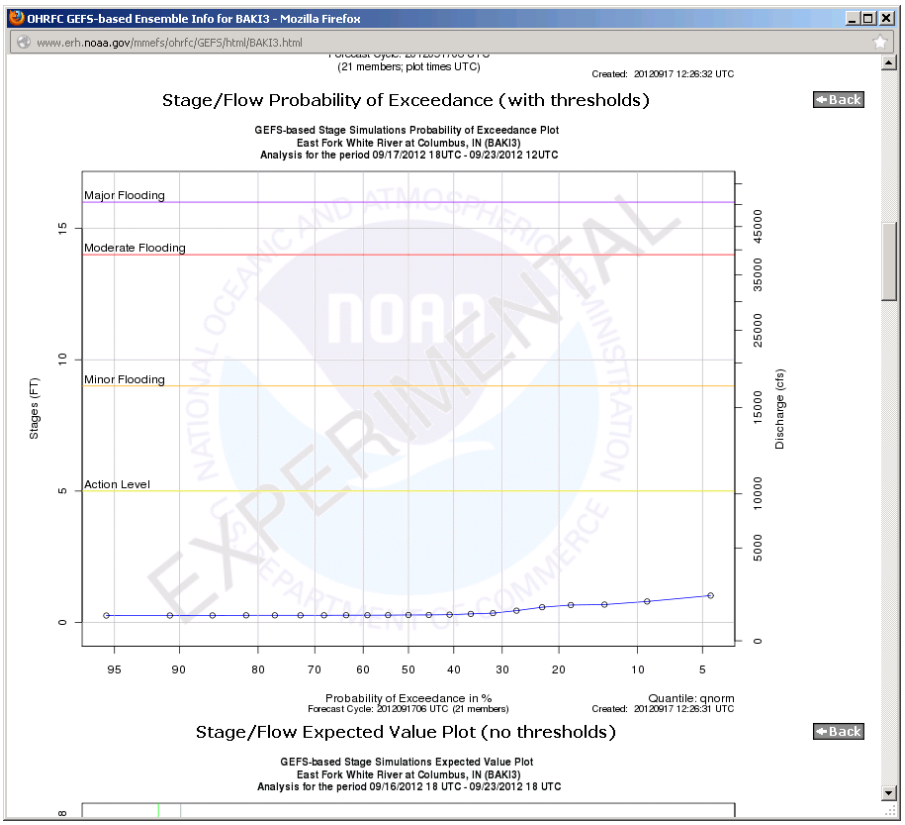

Figure 7: Stage/Flow Probablility of Exceedance

In summary, streams in this category have the following tools available:

- observed and forecasted stages at the USGS gage
- range of uncertainty associated with the forecasted stages, and
- map of expected inundated areas at various USGS gage stages

Forecast Product Category B

Forecast Product Category B streams are similar to Category A streams except that their USGS stream gages are not also NWS river forecast points and do not have forecast uncertainty information available.

Until such time as river stage forecast information is available, only observed stages and USGS inundation mapping is available. The process for obtaining this data is the same as that for Category A streams. The graph of the river stages shown in Figure 3 just will not have the forecasted stage portion and no forecast uncertainty information is available.

In lieu of NWS forecasted river stages, the graph of the observed stages at the gage can provide an indication of whether the stream is still rising or has begun to recede. Educated guesses as to the amount it will continue to rise based on rainfall forecasts for the area can also be made in order to make emergency preparedness decisions. Up to date rainfall forecasts for use in making these decisions can be accessed on the web at the NWS Indianapolis Weather Forecast Office web page currently located at http://www.crh.noaa.gov/ind/. A screen shot of this web page is shown in **Figure 8**. Selecting the "Forecast Graphics" tab on this page accesses the page shown in **Figure 9**.

Figure 8: Page from which Rainfall Forecasts can be Accessed

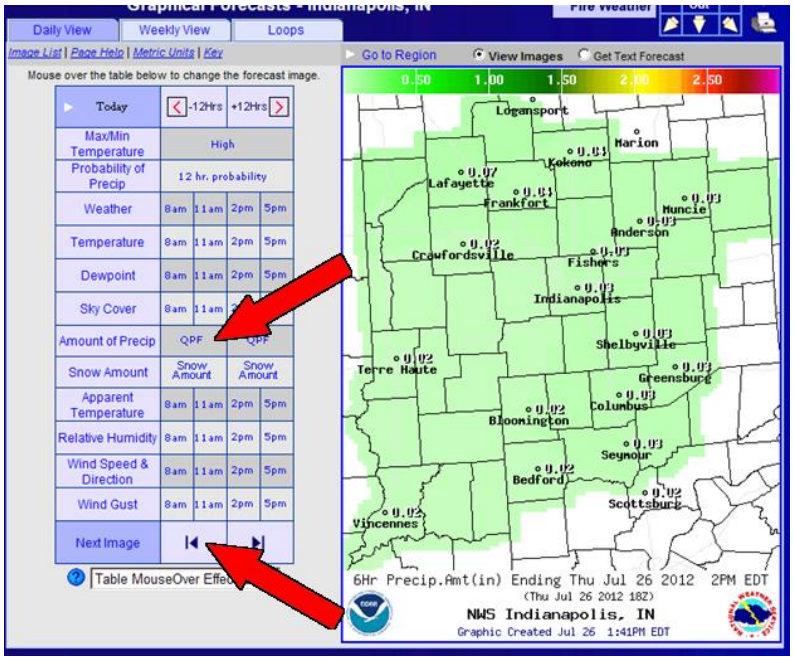

Figure 9: Page for Observed Rainfall Data

Hovering the mouse over the noted "QPF" labels shows the map of the Quantitative Precipitation Forecast (QPF). This map shows the forecasted precipitation totals for the 6-hour increment noted on the bottom of the map. Use of the "Next Image" tab at the bottom gives access to the next 3 days' worth of QPF data.

A more detailed graphic for the 48-hour increment forecasted rainfall total is located on the NWS Ohio River Forecast Center Forecast River Conditions page currently located at http://www.erh.noaa.gov/ohrfc/. Selecting the Forecast Precipitation tab provides the rainfall forecast as shown in **Figure 10**.

Figure 10: Example of 48-Hour Forecasted Precipitation Totals

This is the rainfall data that the NWS forecasters put into their computer models for the period indicated. The graphics don't indicate whether the precipitation is in the form of rain, snow, or sleet, etc. since the model makes that determination by the temperature and other information that is also provided. This map is generated automatically and may be posted before quality control measures are taken on it so it may not be the final form.

During the winter and early spring months, snow melt can be a major factor in flooding. To provide data on that possibility, there is a map of the water equivalent of snow on the ground. **Figure 11** shows an example of the data available from the National Operational Hydrologic Remote Sensing Center Interactive Snow Information map currently available at http://www.nohrsc.noaa.gov/interactive/html/map.html.

Figure 11: Example of Rainfall Equivalent Snow Map

These maps show the water equivalent of the snow. Snow melt is part of the runoff that combines with rainfall runoff to create flooding so if there's a large amount of snow or rainfall on wet snow, knowledge of the equivalent rainfall of the snow on the ground will give a better idea of whether the combined impact on runoff amounts is significant.

In summary, the following information is available for streams in Category B:

- observed stages at USGS gages
- map of expected inundation area at various USGS gage stages, and
- precipitation forecast data for the watersheds

Forecast Product Category C

Data for Category C streams are similar to that described above for the Category B streams with the exception that no inundation map library is available. In lieu of USGS inundation mapping, depth mapping created based on FIS profiles or other studies can be used. Where stream gages exist, this depth mapping can be linked to stages at the USGS gages. This in essence provides depth mapping for 4 stages of the gage ranging from the 10-year to 500-year flood stages. Observed gage stages can be found as at the NWS Indianapolis Weather Forecast Office page at http://www.crh.noaa.gov/ind/. This web address currently displays the screen shown in **Figure 12**.

Figure 12 NWS Internet Page to Access Forecast Products

Clicking on the "Rivers and Lakes" tab shown by the red arrow leads to the page shown in **Figure 13**.

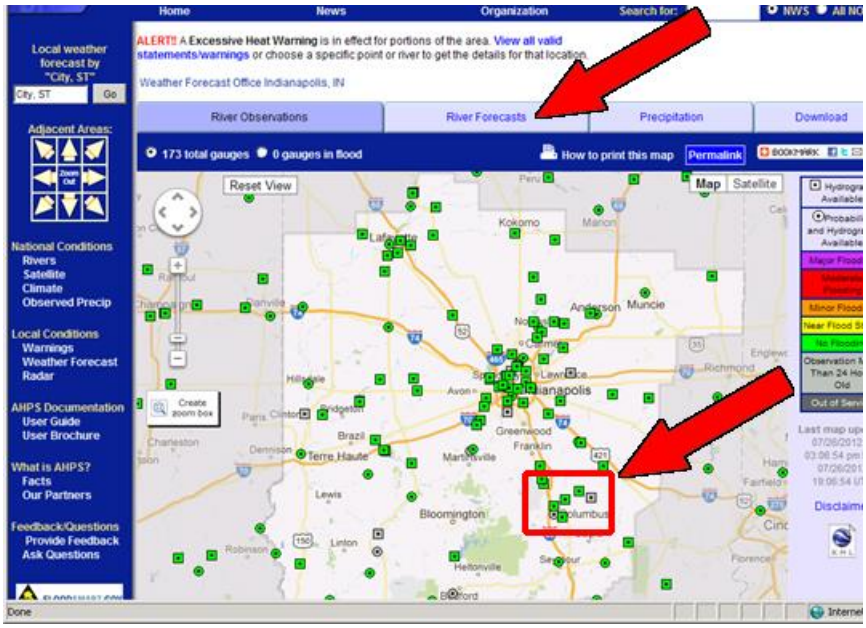

Figure 13 NWS Internet Page to Access River Forecast Products

This map shows the USGS gage station sites with observed data only (as well as those with NWS river forecast data). Clicking on the respective gage icon displays a graph of the observed gage stages as shown by the example in **Figure 14**.

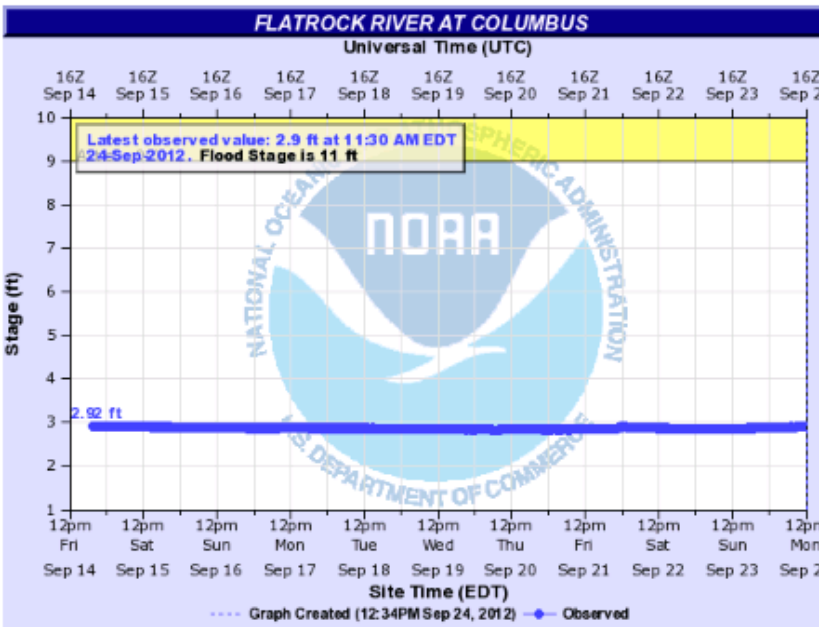

Figure 14 Observed USGS Gage Stages

In lieu of NWS forecast data, the graph of the observed stages at the gage can provide an indication of whether the stream is still rising or has begun to recede. Educated guesses as to the amount it will continue to rise based on rainfall forecasts for the area can also be made in order to make emergency preparedness decisions. Up to date rainfall forecasts for use in making these decisions can be accessed on the web at the NWS Indianapolis Weather Forecast Office web page currently located at http://www.crh.noaa.gov/ind/. A screen shot of this web page is shown in **Figure 15**. Selecting the "Forecast Graphics" tab on this page accesses the page shown in.**Figure 16**.

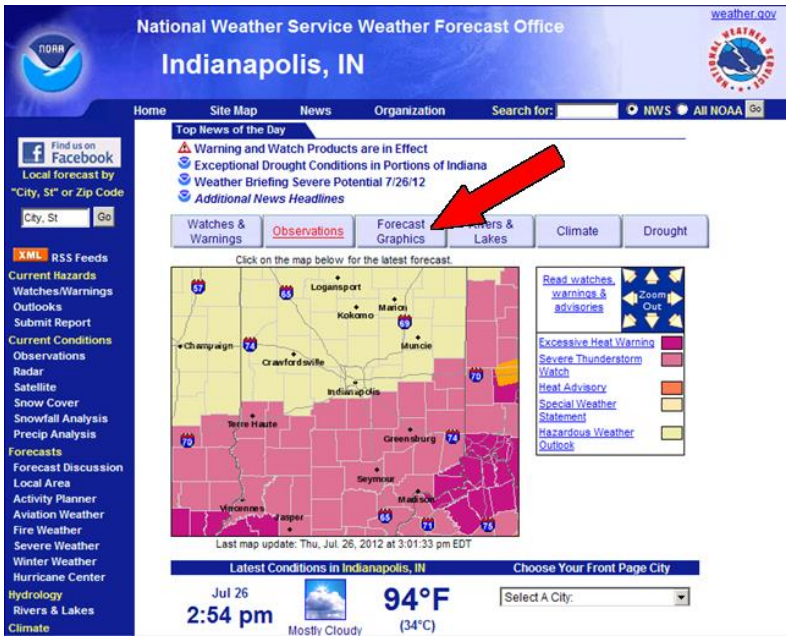

Figure 15 Page from which Rainfall Forecasts can be Accessed

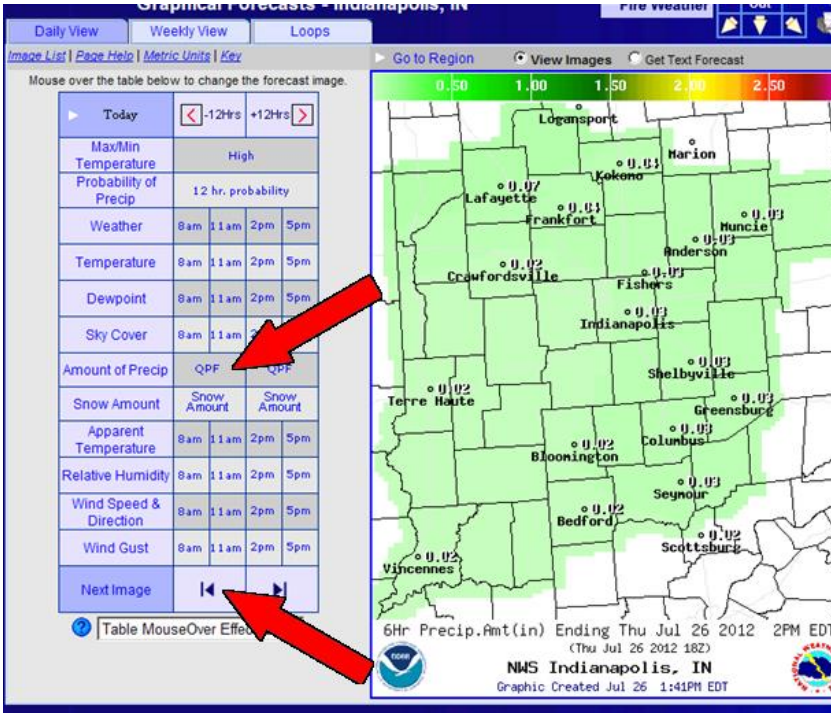

Figure 16 Page for Observing Rainfall Data

Hovering the mouse over the noted "QPF" labels shows the map of the Quantitative Precipitation Forecast (QPF). This map shows the forecasted precipitation totals for the 6-hour increment noted on the bottom of the map. Use of the "Next Image" tab at the bottom gives access to the next 3 days' worth of QPF data.

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Figure 17 Example of 48-Hour Forecasted Precipitation Totals

This is the rainfall data that the NWS forecasters put into their computer models for the period indicated. The graphics don't indicate whether the precipitation is in the form of rain, snow, or sleet, etc. since the model makes that determination by the temperature and other information that is also provided. This map is generated automatically and may be posted before quality control measures are taken on it so it may not be the final form.

During the winter and early spring months, snow melt can be a major factor in flooding. To provide data on that possibility, there is a map of the water equivalent of snow on the ground. **Figure 18** shows an example of the data available from the National Operational Hydrologic Remote Sensing Center Interactive Snow Information map currently available at http://www.nohrsc.noaa.gov/interactive/html/map.html.

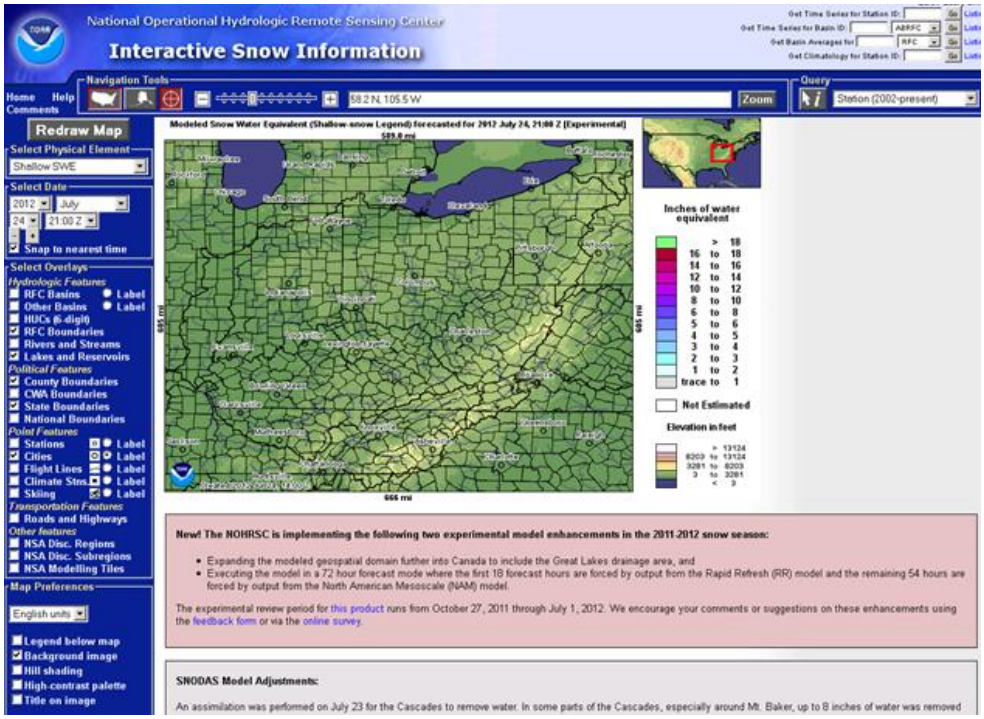

Figure 18 Example of Rainfall Equivalent Snow Map

These maps show the water equivalent of the snow. Snow melt is part of the runoff that combines with rainfall runoff to create flooding so if there's a large amount of snow or rainfall on wet snow, knowledge of the equivalent rainfall of the snow will give a better idea of whether the combined impact on runoff amounts is significant.

In summary, the following information is available for Category c streams:

- observed stage at USGS gages
- depth mapping for 4 frequency floods and associated stages at USGS gages, and
- forecast precipitation data for the watersheds

Forecast Product Category D

Figure 19: Flash Flood Guidance Web Page

Category D streams do not have USGS stream gages to use for forecasting or estimating flood stages but they do have flood depth mapping based on FIS profiles or other studies. Currently, forecasted rainfall depths and flash flood guidance are the only forecast products that are available for these watersheds. The NWS Ohio River Forecast Center Flash Flood Guidance product is accessed from http://www.erh.noaa.gov/ohrfc/FFGuidance.html as shown in **Figure 19**.

From this page, maps that show the rainfall depths in the subsequent 1-, 3-, 6-, 12-, and 24-hours that would potentially create flooding can be selected. **Figure 20** shows an example of the 6-hour Flash Flood Guidance map. At the time this map was created, 3 to 4 inches of rain would have been needed in the next 6 hours before flooding could be expected to have occurred in the Columbus area. The values on the map take current soil moisture conditions into account so are a better indication of the rainfall that could cause streams to start flowing outside their banks. This information is very generalized instead of being specific to a given stream.

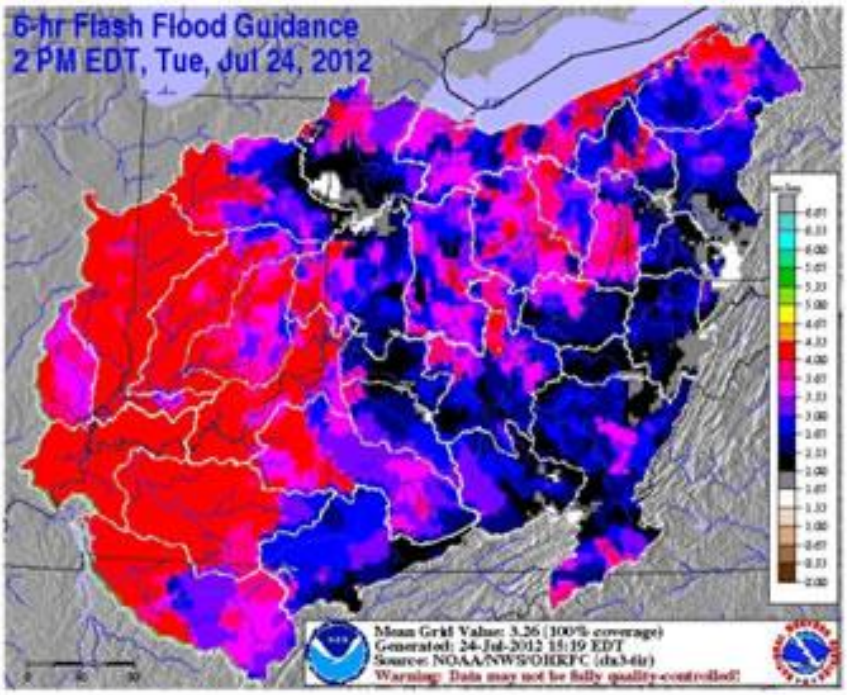

Figure 20 Example of NWS Flash FLood Guidance

A method could be developed for using the flash flood guidance with frequency flood depth maps and knowledge of critical rainfall durations for each watershed to make rough predictions of flood inundation areas for use in flood response plans.

Forecast Product Category E

Figure 22 NWS Flash Flood Guidance Web Page

Category E streams do not have inundation map libraries, depth mapping, USGS stream gage observations, or river forecasts available for use in determining flood response needs. The NWS Flash Flood Guidance product is the most useful product for these streams. It can be obtained from the NWS Ohio River Forecast Center Flash Flood Guidance accessed from the web page shown in **Figure 22** and currently available at http://www.erh.noaa.gov/ohrfc/FFGuidance.html.

From this page, maps that show the rainfall depths in the subsequent 1-, 3-, 6-, 12-, and 24-hours that would potentially create flooding can be selected. As an example, at the time **Figure 21** was created, 3 to 4 inches of rain would have been needed in the next 6 hours before flooding could be expected to have occurred in the Columbus area. The values on the map take current soil moisture conditions into account so are a better indication of the rainfall that could cause streams to start flowing outside their banks. This information is very generalized instead of being specific to a given stream.

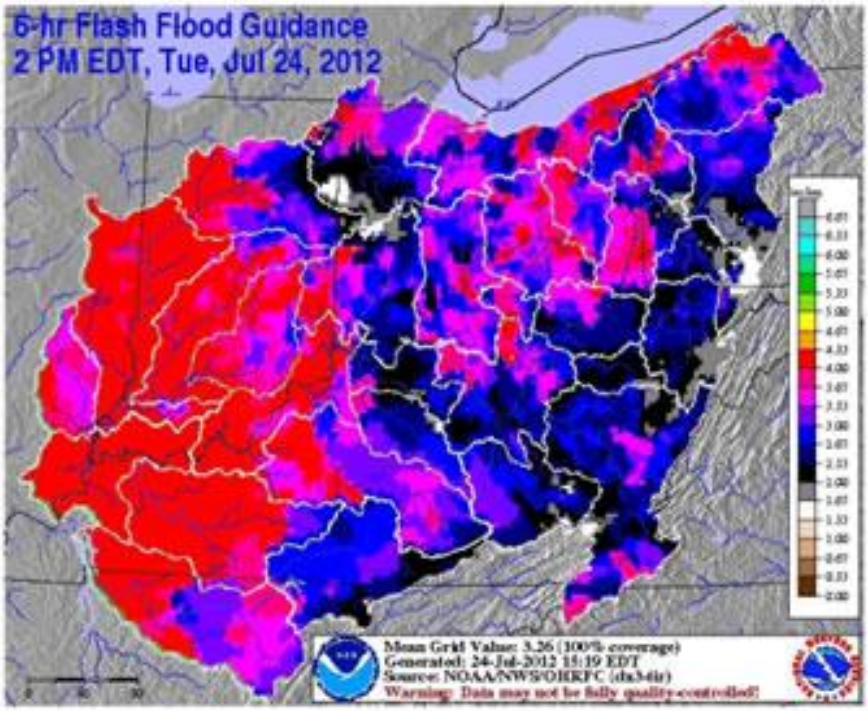

Figure 21 Example of NWS Flash FLood Guidance